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NASA UNMANNED SPACE PROGRAM AT AMR

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~~By: Robert H. Gray~~

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INTRODUCTION

The Manned Space Flight Programs as described to you ~~by Mr. Preston~~ are the major goal of the United States at this time; howver, tremendous strides in space activities other than manned have been made and will continue. This country is now approaching the point where successful satellite launches other than manned satellites rate only minor comments in the newspapers and it takes a failure or major disaster to result in significant press coverage. This is indicative of the progress that has been made in the unmanned space efforts, and seemingly places these efforts in the category of commonplace or routine. When the launch of a man to the moon causes no more news flurry than the launch of a Tiros weather satellite today, the space age will be able to claim maturity.

Because of the large effort and the significant successes in the unmanned programs; the scope of these programs in the future; and the sometimes lack of public appreciation; I would like today to summarize the NASA Unmanned Programs that have and will continue to make use of AMR as a launching site.

DEFINITION OF MISSIONS

I would like to commence by identifying the principal types of missions involved. We classify these as scientific and applications. The scientific missions are for basic research of the environment of the earth as obtained by orbiting satellites; and of the environment of the sun, moon, planets, and interplanetary space by means of earth satellites and space probes. The applications programs make use of space technology in such useful areas as meteorology and communications.

SPACE VEHICLES

At this point it is desirable to identify the space vehicles that are used in these programs. By and large, the booster requirements for the initial needs of the unmanned programs were able to be met by using modified existing space vehicles and military boosters, except in the case of the lunar and planetary probes. This has worked to the advantage of these programs because it has resulted in the development of relatively single purpose specialized satellites which have been launched into orbits uniquely suited to the particular set of experiments which they carry. This is in contrast to what seems to be the Russian approach of launching dewer but larger and thus more general purpose satellites which imposes a handicap in matching the orbit to the experimental requirements. This has resulted in the advantage of the United States being able to launch many small satellites into different orbits for full exploitation of the environment to be studies.

At AMR in the conduct of NASA's unmanned space flight program, three space vehicles are used. These are: The Delta, the Atlas Agena, and the Centaur.

DELTA

The smallest of these three boosters is the Delta, a three stage vehicle which has become the work horse of NASA's scientific and applications programs. The Delta first stage is a modified liquid propellant Thor which, using liquid oxygen and kerosene as propellants produces more than 165,000 pounds of thrust. The second stage is a modified version of the early liquid propellant Vanguard second stage. The engine on this stage produces more than 7,500 pounds of thrust using nitric acid and hydrazine. Guidance for the first and second stages is provided by an inertially stabilized auto-pilot system within each stage. A ground based guidance system is also used to correct in-flight deviations to provide the capability for precise maneuvering into accurate orbits.

The Delta second stage contains a coast attitude control system which is capable of maintaining attitude and providing second stage pointing for periods of up to 30 minutes of coast.

The Delta third stage is a second generation version of the spin-stabilized Vanguard solid propellant third stage. This stage develops a thrust of more than 2700 pounds.

The Delta is capable of boosting payloads weighing up to 800 pounds into a 500 nautical mile circular orbit and can boost a 120 pound spacecraft to escape velocity. The vehicle is capable of providing a wide variety of circular and elliptical orbits over a wide range of inclinations.

Since 1960 Delta has successfully orbited 16 spacecraft in a row. This record includes such satellites as Echo, Tiros, Ariel, Telstar, Relay and Syncom and satellites to measure magnetic fields, radiation belts, solar phenomenon, and atmospheric structures. Since the successful orbit of Echo I in August 1960, Delta vehicles have placed about half of the successful NASA earth satellites into orbit. These satellites have collected many of the basic facts we use today in planning manned and unmanned space exploration.

The Delta vehicle at a cost of about two and one half million dollars and with the demonstrated exceptional high reliability has given a higher return per dollar spent than probably any other space vehicle used by this nation.

In the next few years, Delta will continue to be used in large numbers to launch more Telstar, Tiros, Relay, and Syncom satellites, as well as many other types of satellites for scientific research, such as solar observatories, ionospheric probes, etc.

ATLAS AGENA

The Atlas Agena vehicle is a two stage liquid propellant booster which is capable of placing a 5,000 pound spacecraft into a 300 nautical mile orbit and can boost a 750 pound spacecraft to escape velocity. The first stage is a modified Atlas D which weighs 260,000 pounds and develops about 360,000 pounds of thrust using liquid oxygen and kerosene. The second stage is an Agena powered by a liquid propellant engine which develops 15,000 pounds of thrust using nitric acid and hydrazine. This engine has the capability of being shut down and restarted in space for mission flexibility, and has the capability of maintaining attitude for extended coast periods. The guidance for the first stage is auto-pilot and ground based radio guidance and all inertial for the second stage. (Slide 3 used to show stage and vehicle configuration.)

The Atlas Agena has been used at AMR to launch the Ranger spacecraft and successfully and accurately placed the Mariner fly-by trajectory to investigate the planet Venus. This vehicle will be employed in the future to launch the heavy scientific satellites such as the geophysical and astronomical observatory spacecraft. In addition it will continue to be used for the Ranger lunar flights and the Mariner planetary flights. Other missions such as advanced communications and scientific satellites will also use this vehicle as a booster.

CENTAUR

The Centaur is the newest and most advanced of the Atlas based vehicles. The first stage is Atlas D with cylindrical tankage required to mate with the 10 foot diamter Centaur upper stage. (Slide 3 used to show cylindrical stage I section and second stage configuration). The Centaur second stage is a light-weight, high performance stage using the high energy propellant combination of liquid oxygen and liquid hydrogen. This propellant combination develops over 40 percent more thrust for each pound of propellant consumed per second than the conventional kerosene and oxygen combination.

When it becomes operational in late 1964 Centaur will be capable of injecting 8500 pounds into a low earth orbit and of boosting 2300 pounds to the moon and 1,300 pounds to Venus and Mars.

This vehicle will be used as the booster for the unmanned lunar and planetary exploration projects that are beyond the capability of the Atlas Agena launch vehicle. Other planned missions include advanced communications, meteorological and scientific satellites in high earth orbits as well as high velocity interplanetary probes.

SCIENTIFIC MISSIONS

Now that we have discussed the vehicles that have been and will be used in the unmanned programs at AMR, I would like to talk about the scientific missions that have been or are to be undertaken. For purposes of describing the types of missions and experiments we can divide space into the following general areas - the near earth, the sun, the moon, interplanetary, and planetary.

NEAR EARTH

For the near earth experiments, the studies of interest are measurements of the radiation belt, magnetic fields, ionosphere; and the density and composition of the upper atmosphere. Experiments conducted during the past three years in this regime have resulted in bits and pieces of data sent back from space that are being fitted together by the scientists throughout the nation and the world like a giant jig saw puzzle. The pattern that is emerging is permitting an understanding of the earth's environment and the influence of the sun on the earth's ionosphere, atmosphere, and radiation belts.

Data relating to the earth and the sun-earth relationship has been obtained in some cases inadvertently such as was done by studying the trajectories of Vanguard I and Echo I. Vanguard I, which celebrated its fifth year of transmission from orbit last month has contributed in a large sense to determination of the size and shape of the earth as well as long term cycle effects of the earth gravitational field.

The Echo I balloon, which is very large in relation to its weight, is very responsive to changes in resistance in orbit and its orbital variations have served as a sensitive measurement of the density variations encountered. At a time that a Class 3 solar flare was observed from earth, a marked change in the Echo orbital period was detected.

This data enabled the upper atmosphere physicists to deduce that this flare heated the atmosphere causing it to expand and increase in density at the altitudes of the Echo I orbit. More detailed information has been obtained from the later direct measurements satellites in determining the inter-relationship between the sun and the earth's upper atmosphere.

Many of the experiments in the Near Earth Region were conducted by Explorer Satellites. The first Explorer launched on a Delta was Explorer 10, which was known as P-14 or Magnetometer Probe. This spacecraft carried an extremely sensitive rubidium magnetometer to plot magnetic field intensities to a distance of 145,000 miles. This satellite gathered some of the most definitive data obtained to date on the earth's magnetic field and by coincidence was aloft during a major solar flare which supported existence of solar proton streams or winds transporting magnetic fields past the earth's orbit.

Radiation and magnetic fields surrounding the earth were also extensively studied by Explorers 12 (S-3 Energetic Particles), 14 (S-3a, Energetic Particles), and 15 (S-3b, Energetic Particles), all of which were energetic particle and radiation monitoring satellites; and by Ariel which was the first joint United States and United Kingdom satellite and was designed for ionosphere measurements. The three Explorer satellites confirmed the existence of a ring current of low energy protons circling the earth in a westerly direction, and drifting perpendicular to their perpetual north-south spiraling motion along the geomagnetic field lines. In addition, Explorer 12 (S-3 Energetic Particles) was the first spacecraft to measure the entire cross-sectional [illegible] of the upper and lower Van Allen radiation belts, and proved that there is in reality only one belt with varying intensities.

The ionosphere electron density experiments aboard Ariel (US-UK I International Satellite) showed that electron temperature in the ionosphere depends on latitude, indicating that there is another heat source, possibly caused by the Van Allen belts precipitating particles into the ionosphere. Ariel (US-UK I, International Ionosphere Satellite) also indicated that solar flares have two phases. (Slide 6 shows details of mass spectrometer, electron density and electron temperature).

Explorer 17, the stainless steel Atmospheric Structures Satellite, was the most recent spacecraft launched by Delta, and is now successfully measuring the density, composition, neutral particle temperature, and electron temperature of the earth's upper atmosphere and will aid in determining the variations of these parameters with the time of day, latitude, and season. This satellite in the first few days of its life furnished more information in these areas than all the previously collected information combined.

SOLAR

The next area in space of scientific interest is the sun. Prior to the satellite, it was necessary to study the sun as if through a translucent blindfold because the earth's atmosphere filtered a high percentage of the sun's radiation. NASA began its study of the sun with the orbiting solar observatory commonly called OSO which is capable of observing sun spots and solar flares from above the earth's atmosphere. This spacecraft containing thirteen different experiments for measuring solar radiation is one of a series of satellites designed to monitor the sun over a complete solar cycle.

OSO is one of the most complicated satellites launched to date by NASA and makes use of a solar pointing control system for orienting the experiments and solar cells toward the sun. This system utilizes the entire spacecraft as part of the control platform and uses photo detectors and high pressure gas jets for pointing the scientific instruments.

...as operated for over a year and the data from its experiments exceeds all of the data obtained previously in these areas from ground based observatories, rockets, balloons and satellites combined, and is contributing significantly to unravelling the many mysteries of our solar system.

OSO has observed hundreds of solar flares and has detected regular and predictable patterns in the eruption of small micro flares in the sun and has shown that solar disturbances have a greater electron density than undisturbed areas. These solar eruptions are of a major concern to the people planning manned space flight missions and further measurements will be required to determine the protection a man will need in space.

It appears that for a lunar trip, man can adequately be protected from all but the most extreme solar event. One of the major objectives, therefore, of our solar studies, is to devise ways of accurately predicting major solar events. If this succeeds, manned space shots will be timed to avoid these events just as a ship avoids a hurricane at sea.

Additional studies in this area will be accomplished by more OSOs and with an advanced heavy geophysical observatory satellite known as EGO; which stands for Eccentric Geophysical Observatory. It is called eccentric because of its elliptical or eccentric orbit, A total of 20 experiments will be on board EGO to study earth-sun relationships and will allow scientists for the first time to make continuous simultaneous observations of many geophysical phenomenon.

A series of deep space probes known as the Pioneer series are also programmed for the purpose of monitoring solar radiation.

LUNAR

The next major area of space I will discuss is the moon. NASA's unmanned exploration of the moon and its environment is presently being intensified to support future manned missions. Scientists must know if the moon is radioactive, it its surface has cracks or boulders, and what its temperature is. Three programs are currently underway

The Ranger spacecraft, the first of which was launched by an Atlas Agena booster in 1961, is designed to measure radiation and magnetic fields in the vicinity of the moon, to take close-up picutres of the lunar surface, and to hard land scientific payloads. The Ranger flights to date have developed the spacecraft experiments and an attitude stabilization system, which utilizes earth-sun reference lines, and a mid-course trajectory correction system which were used for the successful Mariner Venus fly-by. Future Range flights are scheduled to help obtain the lunar information required for the manned effort. (Slide 8 shows details of TV, antenna system, spectrometer, retro rocket, etc.).

NASA plans to test soft lunar landing techniques with Surveyor, a more complex spacecraft presently under development. Surveyor, to be launched by a Centaur booster will also survey landing areas on the moon and measure the physical and chemical properities of the lunar surface.

A lunar orbiting Surveyor is also under development. This space craft will use many components of the Surveyor lander, and will provide comprehensive photographic reconnaissance of the moon to complement the data gathered by Ranger and Surveyor lander. (Slide 9 shows details of TV systems, radiation detector, magnetometer, landing legs and surface samplers.)

INTERPLANETARY SPACE

Another area of scientific interest is interplanetary space. It is distinquished from the near earth region because the phenomena here are dominated by the sun and relatively uninfluenced by the earth. Extensive exploration of interplanetary space is being carried out by NASA scientists to aid engineers designing both manned and unmanned spacecraft for planetary missions. Much information about interplanetary space has already been provided by Explorers 10 (P-14) and 14(S-3a) and by Mariner 2, the highly success-Venus fly-by.

Explorer 14 (S-3a) which flew a highly elliptical orbit, studied the electrically charged particles of near space and cosmic rays in the regions beyond. The six experiments on board measured particle energies from a few electron volts to 10 billion electron volts and magnetic field intensities to a lower limit of several gammas.

An orbiting Astronomical Observatory (OAO) to be launched from Cape Canaveral in 1965 is presently under development by NASA. This spacecraft will map the sky in ultraviolet, study certain stars, nebulae, and interstellar matter, from a vantage point above the earth's atmosphere.

PLANETARY

The final types of missions of scientific concern is the planetary missions. The most definitive data collected about another planet to date has been provided by the much publicized Mariner 2 flight past Venus. During its 129 day flight, Mariner 2 transmitted over 65 million bits of information back to earth. As the spacecraft flew a scant 21,000 miles above Venus, its instruments made three scans of the planet-one on the dark side, one on the light side, and one across the line which separates the two.

Based on the results of these experiments, scientists have been able to give a preliminary description of the surface and atmosphere of Venus.

The surface of Venus is dry, sandy, overcast, and hot, with an average temperature of 600° F on both the dark and light sides.

A heavy cloud, 15 to 20 miles thick, covers the planet at a height of 45 miles. The temperature of the cloud is about 200° F at the bottom and -30° F at the center. It is thought that this cloud is composed of hydrocarbons and resembles a kind of smog.

The first NASA Mars fly-by will be by a Mariner which is programmed for launching from the Cape by an Atlas-Agena booster in late 1964. (Slide 12 shows pointing antenna configuration and experiments such as magnetometer.)

It is hoped that the planetary observations made by this spacecraft will provide enough information to determine whether or not life exists on Mars. To accomplish this, it will carry an IR grating spectrometer and a TV system. Mariner will also carry instruments to perform field and particle measurements in interplanetary space during its trip to Mars.

The scientific efforts which I have described are indeed extensive and ambitious. They are planned to enable us to understand the universe and its influence on the earth. In the more recent past we have geared the scientific approach to establishing a close relationship with the manned space program. The distribution of harmful radiation in space, the times of their occurance, the influence of magnetic fields and the composition and environment of the bodies to be explored by man must all be known before we can safely proceed to send man into space.

APPLICATIONS MISSIONS

The other principal part of the NASA unmanned program is the so called applications missions. These programs, utilizing techniques once thought of as science fiction, are of more immediate use and benefit to the peoples of earth and have been progressing at a very rapid pace during the last year or so. The two main areas of applications missions are in meteorology and communications.

METEOROLOGY

Since 1960, six Tiros weather satellites have been orbited from Cape Canaveral, with six attempts. These satellites are designed to prove the feasibility of a satellite meterological system and to establish an operational weather analysis and forecasting program.

The Tiros program has been highly successful. Tiros 3 produced the very first picture of a hurricane - Hurricane Anna - ever obtained from a satellite and Tiros 5, launched into a high inclination orbit, provided the initial warning of half of the world's ten most serious storms in August 1962. Another Tiros charted three major storms in different parts of the world simualtaneously.

NASA's manned space flight program has also benefitted from Tiros, since data obtained from Tiros 4, 5 and 6 was used to provide global weather information for Mercury flights.

The memory storing capabilities of Tiros and the speed with which the data collected by these satellites is made available is quite interesting.

Either of the two Tiros ground stations; which are located at Wallops Island, Virginia, and San Nicholas Island, off the California coast, can command the spacecraft to program and photograph cloud cover or measure infra-red values at any point in the orbit. The spacecraft stores the data and on command rapidly transmits this information to the command station when it is in line of sight.

Repsresentatives from the Weather Bureau and other agencies are always on duty at both Tiros ground stations. Within three hours after the data is received, it is charted and relayed to all participating weather stations in the United States to provide the most up-to-the minute weather forecasting in the world. NASA plans to maintain an operating Tiros in orbit at all times until its successor, Nimbus, becomes operational, so that the studies of the cloud cover coupled with other scientific studies will enable a more accurate and early warning weather forecasting capability for even greater long term benefits to mankind.

COMMUNICATIONS

The other area of applications missions is communications. The first communications satellite launched by NASA at AMR was Echo I, a 100 foot balloon which was placed into a 1000 mile circular orbit. Echo I permitted some of the earliest experiments in passive (reflective) global communications, and, though launched over two years ago, is still in orbit. Because of this unexpected long life, a bonus of valuable scientific data on solar radiation, pressure, and other effects has been collected by scientists.

Also launched as a part of the passive program were two sub orbital tests of a semirigid 135 foot diameter balloon. These tests, called Big Shot, lofted the balloon canister into space and then by means of camera and TV systems on the nearby booster observed the inflation process and stabilization of the balloon during its 30 minute period in space. This program exposed inherent shortcomings in the balloon design which will be corrected prior to orbital flight.

ACTIVE COMMUNICATIONS

In the active communications satellite program, NASA has launched three satellites. Two - Telstar and Relay - are low altitude satellites; while the third is a high altitude synchronous orbit satellite, known as Syncom.

Telstar, the first active communications repeater in space, was developed primarily to determine the feasibility of relieving the communications load on transoceanic cable and radio links, and has opened the way to a tremendous expansion of global communications.

Its broad band microwave repeater provides 600 one-way voice links or one TV channel, or its equivalent in data, teletype, and facsimile transmission. Though not principally designed for two-way telephone conversations, Telstar could provide 60 simultaneous two-way phone conversations. Telstar, in addition obtained extensive and valuable radiation data from special experiments.

Relay, like Telstar before it, is a forerunner of a satellite communications network planned to link all the continents of the earth. The primary objectives of Relay were to test intercontinental microwave communications using low altitude active repeater satellites, measure the energy levels of space radiation in its orbital path, and determine the extent of radiation damage to solar cells and electronic components.

Though a malfunction in its power system prevented scientists from using Relay's communication system at first, changes in the command sequence were made to keep Relay functioning. Relay is the first satellite to link three continents (North and South America and Europe), and was used to conduct the first two-way teletype and simulated voice experiments between the United States and South America. Satellite television communications between the United States and Europe were resumed with the transmission of a portion of the "Today" show to France and England via Relay, and just recently, all Britain was able via Relay to view with exceptional clarity a ceremony conducted in Washington, D. C. honoring Winston Churchill as a citizen of the United States.

Syncom, the most recent communications satellite launched, was designed to determine the feasibility of placing and operating a communications satellite in a synchronous orbit, so that its position in space would remain relatively unchanged with respect to the surface of the earth.

A synchronous orbit was achieved by first placing the spacecraft into an elliptical transfer orbit. At a predetermined time (which occurred at the apogee of the transfer orbit) a small solid propellant motor in the spacecraft was fired and the spacecraft was injected into its circular, synchronous orbit 23,000 miles above the earth. Because of its inclined position in space, Syncom traces a figure eight on the earth's surface.

Though an electrical failure shortly after spacecraft motor burnout has not yet allowed scientists to conduct communications experiments, Syncom has proved the feasibility of the precise launch procedures necessary be being placed into a synchronous orbit.

A great deal more will be accomplished with communications satellites in the future, as NASA plans to place a number of active communications satellites in both high altitude synchronous and low altitude elliptical orbit . These experiments will aid in determining whether the multiple satellite, low altitude system or the three satellite, synchronous orbit system will provide the best global communications network.

PROGRAM ACHIEVEMENTS

The extensive information being gathered from the NASA unmanned spaceflight program is presently being applied to all of this nation's research programs. The success in this program is a high point in the total United States space program, and as we enter a new era of space exploration, with more powerful boosters and more complex spacecraft, the knowledge already gained will provide scientists a solid base to build upon.

For years judging from that which has occurred during the past the prospect of things to come is indeed an exciting one.

VISUAL AIDS

1. Title
2. Delta Vehicle
3. Atlas-Agena and Centaur
4. Explorer 10 (P-14)
5. Explorer 12 (S-3, Energetic Particles)
6. Ariel - UK-1
7. OSO
8. Ranger
9. Surveyor
10. Explorer 14 (S-3a, Energetic Particles)
11. Mariner 2
12. Mariner C
13. Tiros Data Transmission
14. Echo I
15. Telstar
16. Telay
17. Syncom
18. Delta Launch